Name Date

ENGINEERING LAB

Designing a Self-Powered Vehicle

Have you ever built something that did not work as well as you imagined? You are not alone! Engineers design solutions to solve a problem or to meet a need. They often discover that their original design may not perform as expected, or that implementing the solution causes new problems that must be solved. When this happens, engineers brainstorm new ideas. Based on their observations and new understandings, they come up with improved designs. Developing the final design often requires several cycles of planning, building, and testing.

All engineers engage in this process of designing, testing, and redesigning. It is not just applied science, but an approach to problem solving called the *engineering design process*. The process involves three phases:

1. Defining the engineering problem by identifying criteria for success and constraints on the design
2. Designing, testing, and evaluating several possible solutions
3. Optimizing the design solution

Your team has been selected to design a self-powered vehicle for the company Next Generation Toys. The company believes a self-powered vehicle would be a great addition to its new line of environmentally friendly toys, which are constructed with everyday and recycled materials. The toy company intends to market the vehicle to children ages 8–11. Next Generation Toys would like the vehicle to travel a distance of at least 3 m unassisted and perform on both flat and inclined surfaces.

DESIGN CHALLENGE Design, build, test, and modify a self-powered vehicle that can travel a distance of at least 3 m, performs on both flat and inclined surfaces, and is suitable for elementary-aged children.

POSSIBLE MATERIALS

- safety goggles
- balloons, nonlatex
- balsa wood
- cardboard, corrugated
- clay
- coat hanger
- craft sticks
- dowel rods (thin, for axles)
- foam core
- kite string
- mousetraps
- paper clips
- propeller assemblies
- rubber bands
- scissors
- soda bottles, plastic
- straws
- tape
- wheels (Wheels may be premade, bottle caps, or cut from other materials.)

SAFETY INFORMATION

- Wear safety goggles during the setup, hands-on, and takedown segments of the activity.
- Use caution when using sharp tools, which can cut or puncture skin.
- Wash your hands with soap and water immediately after completing this activity.

CONDUCT RESEARCH

Research self-powered classroom cars. What are the common elements of their design? What different types of power sources do they use? Think about how the features of classroom cars may be relevant to your design work for toy vehicles.

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DEFINE THE PROBLEM

1. Write a statement identifying the problem you are designing a solution for. How will you evaluate your design?

2. Identify the criteria for a successful solution. Should the efficient use of materials or the vehicle's appearance be taken into consideration? What considerations are necessary for the target user base?

3. Identify the constraints that will affect a successful solution. For example, what are the limitations in materials, time, or other factors? What constraints are related to the target user base?

DESIGN SOLUTIONS

1. As a team, brainstorm at least three possible solutions to the problem. Make sure that you consider ideas from each group member.

2. In your Evidence Notebook, make a decision matrix to choose the solution that best meets the criteria you identified. The decision matrix should list each criterion separately, as well as provide a numerical scoring system to evaluate each proposed solution. You might consider having each member of your group score the designs separately and then share your rankings. Discuss any significant differences in how group members rank the designs. You may need to refine or revise your criteria, then reevaluate your proposed solutions.

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3. Once you have chosen a potential solution, make a sketch of your prototype design. Identify the system components that might be best if developed separately rather than as part of the overall design.

4. Identify and describe the energy conversions needed in your design.

5. In your Evidence Notebook, develop a plan for building your prototype. Assign each member of your group equal amounts of work. Remember that you can prototype, test, and optimize parts of your design separately. As you develop the plan, make sure to note the materials and technology that you will use. You should also include a timeline for the work with defined checkpoints for communication among group members.

6. Have your teacher approve your plan, then build your prototype. As you proceed, if you need to change important parts of your plan, consult with your teacher again.

TEST

1. In your Evidence Notebook, develop an initial plan for testing your prototype. Write out a description of your plan, and make sure to include:
    - methods you will use
    - how you will test the system components
    - how and when to test the fully assembled vehicle
    - materials and technology you will need
    - necessary safety procedures

2. Consult with your teacher to make sure that the conditions you have chosen are appropriate. Then test your prototype to determine whether it meets the most important criteria for an effective solution.

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OPTIMIZE

Share your model with other teams. Demonstrate your prototype, and explain how it meets the criteria for success. Elicit other teams' feedback on your design. Use their comments and critiques to improve your prototype. Test it again as many times as necessary.

1. What tradeoffs can you make to meet the criteria more fully?

2. Draw and label a diagram of your final optimized design.

ANALYZE

1. Describe the major changes you made from the initial to the final design. What features did you have to redesign to meet the criteria?

2. What constraints most limited your design?

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3. What tradeoffs did you make? Explain your reasoning for each choice.

4. Did you encounter any obstacles in the construction or performance of your vehicle? Explain. What steps or improvements did you make to address these difficulties?

5. List one small, realistic change that you could make, and one ideal change that you would make if you had the resources. Explain how each would improve the vehicle.

6. What do you want to remember to do in the same way or in a different way the next time you design a mechanical solution to a problem?

COMMUNICATE

1. Think about your design, one or two of the best designs produced by others in your class, and perhaps a design found through research. Compare the designs to identify best practices in the design of self-powered vehicles. Make a claim stating what you think would be the best design for a self-powered toy car, given the parameters of the challenge. Use data and observations from your work and from the classroom testing of other students' designs as evidence to support your claim. Provide your reasoning so that you connect the evidence you choose to the claims you make.

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2. Suppose you are a member of the marketing team for Next Generation Toys. Create a 2-minute sales-pitch explaining the features of your new self-powered toy vehicle, with special attention to the criteria, constraints, and target user base. Write an outline of your presentation below.

EXTEND

1. Suppose you were a team member engineering an actual vehicle for the 21st century. What criteria for success would you use to evaluate possible designs? What constraints might you encounter in developing a final design? Explain.

2. If you could design a new vehicle with different limitations, what would you change? Would you change the power source, the size or mass, or the materials? Would you change the criteria for success? If so, how?

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